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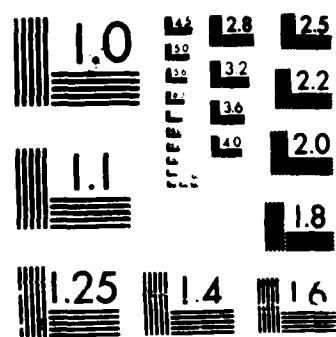
THE OCCURRENCE OF HEARING LOSS IN A COHORT OF CIVILIANS 1/1
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THE OCCURRENCE OF HEARING LOSS IN A COHORT OF CIVILIANS
EMPLOYED AT A U.S. NAVY INDUSTRIAL FACILITY

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SUMMARY

Problem

Although hearing loss has been the focus of national surveys in the civilian population, these surveys typically do not include occupational exposure information. Furthermore, very few studies have addressed this problem in the military, particularly in industrial settings. Audiometric data, including hearing loss information, recorded and stored in the prototype application of the Navy's Occupational Health Information Management System (NOHIMS) has not been systematically evaluated to identify military and civilian populations that are at high risk for hearing loss.

Objective

The objective of this study was to determine the prevalence of hearing loss in a cohort of Navy civilian workers employed at an industrialized facility. It is both appropriate and timely to look at hearing loss among civilian workers, as well as among the military, especially in relation to the recent Presidential initiative that established a government-wide five year goal of reducing civilian workplace injury/illness three percent per year.

Approach

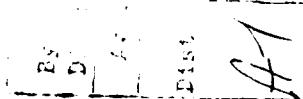
Six hundred and thirty males employed at the NAS North Island Naval Air Rework Facility who had received both a reference and monitoring audiogram during the period Aug 1984 to Feb 1986 formed the study population. Each audiogram tested mean hearing thresholds at six required frequencies; 500, 1000, 2000, 3000, 4000, and 6000 Hz. Medical Query Language (MQL) techniques were applied to the medical and personnel data bases of NOHIMS to extract the audiometric data. Within each occupational group the Student's t test for paired samples was used to test for differences between mean hearing levels reported on the reference and most recent audiograms.

Results

Three of 12 occupational groups did not exhibit a statistically significant change of mean hearing levels between the reference and current audiogram at any frequency. The other groups experienced some degree of significant deficit in mean hearing threshold at some time during the 18-month study period. Results reflect a group's collective audiometric experience and not individual differences. The audiometric profile for metal workers is that commonly associated with undifferentiated sensorineural hearing loss at high frequencies (3000 to 6000 Hz).

Conclusions

This study represents the first attempt to use NOHIMS' medical, personnel, and environmental data for research purposes. The cross-referencing features and file structure of NOHIMS coupled with the compatibility of COSTAR and MQL has provided the means to define cohorts of industrial populations and to evaluate health outcomes. Although audiometric and noise survey data are the first available from NOHIMS future research may be directed to a wide variety of medical outcomes in both civilian and military populations working in many different environments.



INTRODUCTION

Since 1984 the Branch Medical Clinic located at the Naval Air Station, North Island (NASNI), San Diego, California has collected comprehensive audiometric data on civilian personnel during physical examinations, injury examinations, and protective equipment assignment. The information gathered from these examinations is recorded and stored along with basic demographic and occupational information in the Navy's Occupational Health Information Management System (NOHIMS) developed at the Naval Health Research Center in San Diego, California^{1,2}. Hearing tests are conducted at established intervals in accordance with the audiology component of the Navy Hearing Conservation Program³. This study uses the medical and environmental data modules of NOHIMS to determine noise exposure information and the prevalence of hearing loss in a cohort of civilians employed at NASNI.

The Navy Hearing Conservation Program is designed for military and civilian personnel who routinely work in hazardous noise areas and are, therefore, at risk for acquiring permanent noise-induced sensorineural hearing loss as a result of hazardous noise exposure. Periodic audiometric monitoring is a mechanism for preventing temporary threshold shifts (TTS) in hearing ability from progressing to permanent hearing damage. Further, audiometric monitoring is required in order to detect any shifts in hearing early on so that intervention strategies, counseling, and follow-up can be initiated.

Periodic audiometry is an objective means of determining an individual's compliance with the hearing conservation program. By comparing a baseline (reference) audiogram generated prior to occupational noise exposure with subsequent audiograms at established intervals (monitoring or periodic audiograms) changes in hearing ability may be readily detected.

Noise-induced hearing loss (NIHL) is a high-frequency phenomenon which manifests audiometrically between 3000 and 6000 Hz, typically beginning at 4000 Hz. With repeated exposure to intense noise levels over time, the unprotected ears will progressively lose hearing sensitivity. Audiometrically, NIHL that begins at 3000-4000 Hz will continue to increase (e.g., more sound energy is required to hear equivalent to elevated hearing threshold levels on the audiogram) and broaden to affect frequencies below 3000 Hz -- the all important speech frequencies critical for receiving speech information.

Although hearing loss has been the focus of national surveys in the civilian population, these surveys typically do not include occupational exposure information^{4,5} or specific audiometric data⁵. Few studies have addressed hearing loss in military industrial settings particularly where there is a mix of military and civilian workers. In 1971, a pilot study conducted by Walden and colleagues⁶ on the extent of hearing loss in U.S. Army personnel, suggested that NIHL may be the most common occupationally-related disability among Army troops. They estimated that 40-50 percent of all personnel in the combat arms branches for more than 10 years may develop hearing losses sufficient to significantly interfere with job performance.

A 1975 follow-up study was conducted by Walden⁷ in which audiometric and questionnaire data were obtained from 3000 enlisted men representing 3 Army combat branches (infantry, armor, and artillery) and 5 time-in-service categories. The results indicated that the prevalence of hearing loss was approximately the same in the three combat branches; however, there were substantial differences in the prevalence of hearing loss for the five time-in-service categories. While

approximately 20-30 percent of all personnel with two or more years of service had clinically significant hearing loss, among soldiers with 15 or more years of service the percentage exceeded 50 percent. Hearing loss in the Army is almost exclusively a problem affecting the mid- to high-frequency range (3000 to 8000 Hz) with little loss observed below 2000 Hz. The authors concluded that it was not surprising that speech reception thresholds were relatively normal for the vast majority of the 3000 subjects.

The first major study of the prevalence of hearing loss in Navy personnel, conducted by Robertson and colleagues in 1978, indicated that there were decreased re-enlistments among personnel who had worked in high intensity noise environments and more individuals were filing claims for NIHL⁸. The study ranked the 15 most noise-exposed and the 10 least noise-exposed Navy occupational ratings and designated these as experimental and control groups respectively. In addition to audiometric testing, subjects completed questionnaires on medical history and past and current noise exposure history.

Results were compared to those of Walden⁷ for the U.S. Army and a U.S. Public Health Service Survey⁴ and showed that over one-third (37%) of the experimental subjects and nearly one-quarter (23%) of the control subjects experienced significant high-frequency loss beyond five years of service. Over 60 percent of the equipment operators and machinists mates with 15 or more years of service experienced significant high frequency hearing loss. These hearing losses may be an expression of the deterioration of hearing with increased age, occupational exposure, or a combination of the two. In addition, it was found that hearing levels in firemen changed very rapidly after their recruit training but did not differ significantly between 0-1 and 3-4 yrs of service. The hearing sensitivity of the Navy's average 20 year-old fireman was found to be similar to that of the average 40 year-old male in the general population.

More recently, Gwin and Lacroix⁹ utilized a random sample of information derived from the Navy Hearing Conservation Program during the years 1979-82 in order to assess the prevalence of hearing loss, the magnitude of noise exposure, and the use of ear protectors among submariners and Naval Submarine Support Facility (NSSF) workers. Sound levels were found to greatly exceed 85 dBA and even 100 dBA in both submarines and NSSF facilities, and a significant threshold shift (15 dB or more) was found in 20 percent of the subjects on annual re-test. The hearing threshold levels of submariners were found to be consistently elevated relative to the age-controlled norm. This study did not note whether the NSSF support workers were civilians, military, or both.

It is both appropriate and timely to look at hearing loss in noise-exposed civilian workers as well as in their military counterparts working in a common environment especially in relation to the recent Presidential initiative that establishes a government-wide five-year goal of reducing civilian workplace injury/illness three percent per year¹⁰.

METHODS

Study Population

The study population consisted of 630 males, employed at the Naval Air Rework Facility (NARF) located at NASNI, San Diego, CA, who had received both a reference audiogram and a monitoring audiogram during the 18-month period between August 1984 and February 1986. At least one year elapsed between the two audiometric evaluations.

The men were grouped into 12 occupational categories based on the general work environment, tasks performed, and assigned job title (in accordance with General Schedule and Wage Board codes)¹¹.

Work Environment

The NARP in San Diego is the Navy's largest rework facility providing a wide range of engineering, calibration, manufacturing, overhaul, and repair services for ships and for four major lines of aircraft. The NARP consists of 87 buildings with a total area of approximately 2.8 million sq. ft. and is staffed by over 5200 personnel with 52 trade skills and an average of 12 years' experience.

Table 1 provides ambient noise survey information for the multiple worksites that occupational groups may encounter during a typical workday. This information was extracted from the environmental module of NOHIMS. Initially, for the prototype NOHIMS installation at NASNI, only noise survey data from 1983-84 was collected and, therefore, does not provide a comprehensive noise exposure history for NARP workers employed prior to 1983. Complete and reliable data were available for workplaces of 35 percent (221 of 630) of the study population. In many cases, workplace noise surveys are ongoing and had not been completed in time to be entered into the environmental module of NOHIMS. The time-weighted average noise level for all the surveyed workplaces combined was 92.3 dBA with a range of 63.0 to 118.5. Additional survey information included peak noise measurements which averaged 111.3 dBA with a low of 92.0 and a high of 133.0. Potentially hazardous noise levels are considered to be greater than 84 dBA for steady-state (continuous) noise and 140 dB peak sound pressure level for impulse (impact) noise.

TABLE 1
AMBIENT NOISE LEVELS TO WHICH SELECTED NARP OCCUPATIONAL GROUPS ARE TYPICALLY EXPOSED

Occupational Category	No.	Noise Level Range (dBA)	Mean TWA*	SD**(TWA)
Graphics, Audio Visual	7	80.0 - 89.5	86.6	3.8
Electrical	25	75.3 - 118.5	97.6	13.6
Machinists	8	76.0 - 99.0	83.7	13.3
Metal Work	58	81.3 - 103.1	92.0	5.7
Wood, Rubber, Plastic	36	80.6 - 98.1	87.8	6.1
Mechanics	87	63.0 - 118.5	93.6	13.3
Total	221***	63.0 - 118.5	92.3	11.1

*Time-weighted Average noise levels experienced over a normal 8-hour workday or 40-hour workweek.

**Standard Deviation.

***Individuals for whom complete noise surveys had been conducted at their typical workplaces.

Audiometric Evaluation

Audiograms are required for all individuals who will be assigned to or who are currently employed in designated noise hazardous areas. These individuals routinely work with equipment

which produces sound levels greater than 84 dBA for steady-state noise and 140 dB peak sound pressure for impact or impulse noise. Employees who had a reference audiogram but not a periodic hearing test recorded in their health record were excluded from the study. Approximately 45 percent of the audiometric evaluations were conducted on workers already employed at the NARF and the remainder on individuals undergoing pre-placement screening.

Every effort was made to ensure that workers were tested after a noise-free period of at least 14 hours in accordance with both Navy³ and Federal¹² standards. This interval allows for recovery from TTS that may have occurred as a result of exposure to occupational or recreational noise. As a matter of policy at the NARF all reference audiograms (DD Form 2215) and monitoring audiograms (DD Form 2216) are conducted prior to the workshift in an effort to control for TTS as much as possible. Thus, the hearing threshold levels demonstrated on the audiograms may be viewed as valid representations of an individual's hearing sensitivity at that point in time (assuming the ear is free of pathology such as an infection).

Audiometric testing was conducted at the Branch Medical Clinic by NASNI personnel trained as audiometric technicians through a Navy-sponsored hearing conservation certification workshop. The workshop met all guidelines set forth by the Council for Accreditation in Occupational Hearing Conservation (CAOHC) and was conducted by a CAOHC-certified course director (JHS, one of the authors, supervised the audiometric technicians and developed the Navy hearing conservation program at San Diego).

Hearing tests were conducted in a standard, sound-treated audiometric chamber that met all ANSI internal ambient sound level and certification requirements¹³. Audiometers conformed with ANSI standards and met all calibration requirements¹⁴. Each ear was tested at 500, 1000, 2000, 3000, 4000, and 6000 Hz.

The lowest frequency tested for hearing conservation screening purposes, 500 Hz, virtually is never affected by noise exposure. It is not considered to be relevant for our purposes and thresholds obtained at 500 Hz are, therefore, not reported.

When audiometric comparisons were made between occupational groups, an age-weighted, "normalized" hearing threshold curve for the population(s) from which these groups were drawn was presented with each figure. This curve is based on the cumulative age distribution of the occupational group(s) under consideration and the presbycusis adjustment values recommended by NIOSH¹². These values are specific for age, sex, and frequency and take account of the deterioration of hearing caused by the process of aging. The calculation of the five frequency points of each curve are described elsewhere¹⁵.

Analyses

Medical Query Language (MQL), a high-level procedural language developed by the Laboratory of Computer Science of the Massachusetts General Hospital¹⁶, was applied to medical and personnel data bases that are part of the prototype NOHIMS system. COSTAR is the medical application system around which NOHIMS is structured. Both MQL and COSTAR are written in ANSI standard MUMPS. The standard MUMPS computer language is a general purpose, interpretative, high-level programming language designed for interactive data management. Its string-handling features and hierarchically structured data base suit it for medical, inventory, and business applications where large complex files must be designed, constructed, and maintained.

MQL was used to extract the audiometric data from the COSTAR system. Routines written in MQL searched the NOHIMS medical data base and determined the earliest reference audiogram for each individual (n=2302). A second query routine extracted the most recent monitoring (current) audiogram for that individual (n=808). Additionally, basic demographic information such as date of birth and job title were extracted from the administrative division of NOHIMS.

Mean hearing levels were calculated for each tested frequency (except 500 Hz) for both the left and right ear. Previous research on the hearing characteristics of blue-collar noise-exposed populations has shown that hearing thresholds in each ear were highly correlated at eight tested frequencies (.5K, 1K, 2K, 3K, 4K, 5K, 6K, and 8K HZ) suggesting that both ears are essentially affected equally by occupational noise¹⁵. In this study we have combined the audiometric results from both ears as representative of an individual's hearing.

Within each occupational group the Student's t test for paired-samples (correlated measures)^{17,18} was used to test the significance of the difference between mean hearing levels reported on the reference and the most recent monitoring audiogram. These paired-samples represent groups of workers who had received both a reference audiogram and a monitoring audiogram at five specified frequencies.

RESULTS

Table 2 presents the distribution of workers within the NARF by age and occupational group. The average age of this population was 44.6 years as of February 1986 with a range of 21 to 65 years. The youngest group were the firemen (38.9 years) and the two oldest groups were material control and metal workers (48.9 and 48.4 years, respectively).

TABLE 2
DISTRIBUTION OF WORKERS BY AGE AND OCCUPATIONAL GROUP AT THE
NASNI NAVAL AIR REWORK FACILITY

Occupational Category	No.	%	Mean Age	SD* (Age)
Graphics, Audiovisual	53	8.4	45.1	11.2
Material Control	13	2.1	48.9	10.1
Quality Assurance	83	13.2	47.8	8.0
Electrical	35	5.5	45.0	9.1
Machinists	23	3.7	44.0	10.9
Metal Work	73	11.6	48.4	11.4
Wood, Rubber, Plastics	67	10.6	43.9	10.5
Transportation	30	4.8	43.8	8.6
Mechanics	121	19.2	42.5	10.1
Warehousemen	27	4.3	45.3	9.6
Firemen	53	8.4	38.9	10.2
Miscellaneous, other	52	8.2	44.1	10.7
Total	630	100.0	44.6	10.4

*Standard Deviation

Table 3 summarizes the mean hearing levels among the 12 occupational groups at the NARF for both reference and current audiograms at 5 specified frequencies. Three of the groups (material control, firemen, and electrical) did not exhibit a statistically significant change in mean hearing levels between the reference and current audiogram at any frequency and are not shown. Each of the other groups, however, experienced some degree of statistically significant deficit in mean hearing threshold at sometime during the 18-month study period.

TABLE 3
MEAN HEARING THRESHOLDS AMONG NARF EMPLOYEES BY OCCUPATIONAL CATEGORY

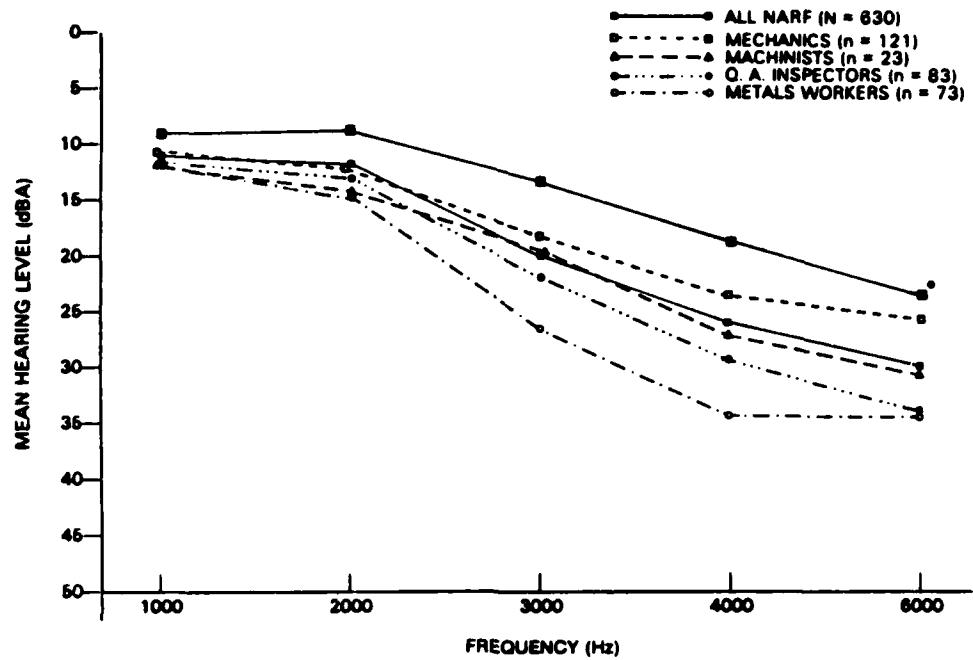
Occupational Category	No.	Frequency									
		1000 Hz		2000 Hz		3000 Hz		4000 Hz		6000 Hz	
		Ref	Cur	Ref	Cur	Ref	Cur	Ref	Cur	Ref	Cur
Graphics, A.V.	53	12.3	13.2	13.5	14.1	19.6	19.6	27.1	28.5*	29.2	31.6*
Material Control	13	10.8	10.4	12.7	12.5	19.4	18.9	26.5	27.3	35.2	33.3
Q.A. Inspectors	83	12.1	12.9*	13.1	13.9	21.0	23.0***	28.2	30.6***	34.2	34.9
Electrical	35	8.8	9.9	9.6	10.9	16.1	17.5	22.7	23.9	23.8	25.9
Machinists	23	12.3	12.7	14.0	13.8	20.8	22.1	27.1	29.8*	30.6	34.3**
Metals Work	73	12.3	12.6	14.9	16.5	27.2	29.2*	34.3	36.9*	34.2	37.2**
Wood, Rubber,											
Plastic	67	13.0	14.0	12.6	13.2	19.6	20.5	27.7	28.7	28.9	30.3*
Transportation	30	12.3	12.7	14.1	15.3	20.3	20.7	25.2	26.9*	27.5	28.5
Mechanics	121	11.0	10.9	11.9	11.6	17.6	18.2	23.4	24.6*	26.2	27.4*
Warehousemen	27	9.2	11.6**	10.2	12.2*	15.5	16.1	23.4	25.3	27.8	29.3
Firemen	53	9.7	10.3	8.5	9.0	14.2	15.7	19.9	22.2	21.7	23.3
Miscellaneous, other	52	10.4	10.7	13.0	13.4	18.4	18.6	26.8	28.8*	30.0	30.9
Total	630	11.4	11.9	12.4	13.0	19.4	20.4	26.3	28.1	29.0	30.5

*p < .05

**p < .01

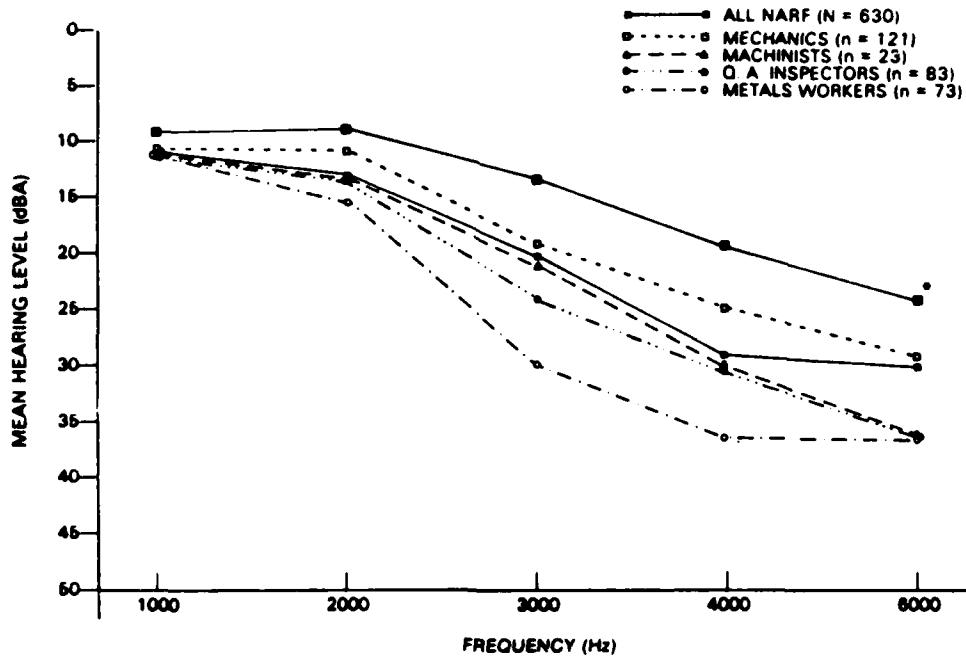
***p < .001

Figures 1 and 2 provide a graphic representation of those occupational groups that had the highest mean hearing levels for reference and current audiograms respectively. The audiometric profile for metal workers is that commonly associated with undifferentiated sensorineural hearing loss at high frequencies (3000 to 6000 Hz). This high-frequency loss is characterized by the 4000 Hz "notch" that is recognized as the principal audiometric feature of a hearing loss resulting from excessive auditory stimulation. Although duration of exposure is not specifically addressed in this study, the ambient noise levels reported in Table 1 support the audiometric profiles presented in Figures 1 and 2 and are suggestive of prolonged and continuous exposure.



*Age-weighted "normalized" hearing threshold levels based on the age distribution of workers in the NARF population and presbycusis adjustment values

Fig. 1. Mean hearing levels from reference audiogram for selected NARF occupational groups.



*Age-weighted "normalized" hearing threshold levels based on the age distribution of workers in the NARF population and presbycusis adjustment values

Fig. 2. Mean hearing levels from current audiogram for selected NARF occupational groups.

Table 4 and Figure 3 highlight the mean hearing thresholds between reference and current audiograms by age-group for those occupational groups identified as having significant losses. In Table 4, two established trends can be readily observed. First, within each of the occupational groups, and at each frequency, there is a steady increase of mean hearing thresholds as age increases supporting the widely accepted observation that ears, especially unprotected ears, progressively lose hearing sensitivity over time. Second, within each occupational group and age group greater than 24 years, mean hearing thresholds steadily increase as frequency increases. These trends are most noticeable in the two oldest age groups among metal workers and quality assurance inspectors at 3000, 4000, and 6000 Hz.

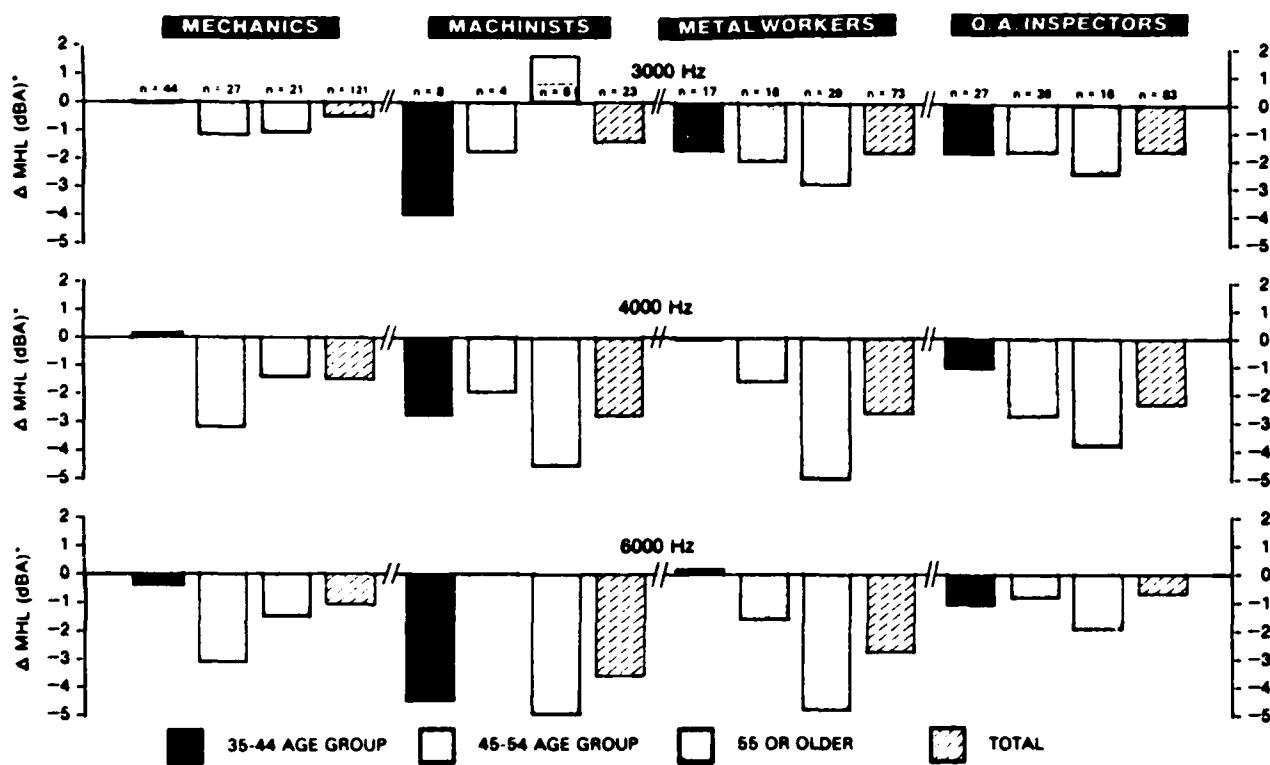


Fig. 3 Differences in mean hearing levels between reference and current audiograms by occupational group, age and tested frequency

*Mean Hearing Level Reference - Mean Hearing Level Current

The arithmetic differences between age-group specific mean hearing levels from reference and current audiograms for the four selected occupational categories is presented in Figure 3. Among metal workers at all tested frequencies and quality assurance inspectors at 4000 Hz there is a steadily increasing difference between reference and current mean hearing levels as age increases. The improvement in hearing noted for the oldest machinists at 3000 Hz (33.8 dBA - reference and 32.1 dBA - current) may be artifactual since the findings are based on few observations (n=6).

TABLE 4
MEAN HEARING THRESHOLDS AMONG NARP EMPLOYEES BY SELECTED OCCUPATIONAL CATEGORY AND AGE-GROUP

Occupational Category	Frequency (Hz)	<u>≤24</u>		<u>25-34</u>		<u>35-44</u>		<u>Age Group 45-54</u>		<u>≥55</u>		Ref Total	Cur
		Ref	Cur	Ref	Cur	Ref	Cur	Ref	Cur	Ref	Cur		
Q.A. Inspectors (n = 83)	1000	-	-	6.9	8.7	9.1	9.8	12.2	12.8	18.3	19.7	12.1	12.9
	2000	-	-	7.5	6.9	7.6	8.1	13.2	14.6	23.6	25.6	13.1	13.9
	3000	-	-	6.2	6.2	12.4	14.4*	21.2	23.1*	38.9	41.3	21.0	23.0***
	4000	-	-	11.9	12.5	19.1	20.3	26.4	29.2*	51.9	55.8*	28.2	30.6***
	6000	-	(n = 0)	15.0	9.4	23.5	24.9	32.9	34.0	59.8	60.0	34.2	34.9
Mechanics (n = 121)	1000	-	-	8.3	7.8	10.2	10.8	10.9	10.2	17.0	16.9	11.0	10.9
	2000	-	-	5.7	4.3	10.6	10.5	12.7	12.7	23.0	22.7	11.9	11.6
	3000	-	-	6.9	7.8	16.6	16.7	20.7	22.0	30.5	31.7	17.6	18.2
	4000	-	-	10.9	11.9	22.4	22.3	27.3	30.6*	38.9	40.1	23.4	24.6*
	6000	-	(n = 0)	15.6	15.8	23.9	24.4	29.0	32.2***	43.1	44.6	26.2	27.4*
Metals Work (n = 73)	1000	-	-	8.2	7.7	12.1	10.7	10.5	11.4	15.0	16.1	12.3	12.6
	2000	-	-	7.5	8.6	11.5	10.4	14.2	14.8	20.2	23.9	14.9	16.5
	3000	-	-	7.7	8.2	14.1	15.7	28.3	30.3	41.6	44.5	27.2	29.2*
	4000	-	-	15.7	16.0	19.6	19.7	36.6	38.3	48.8	54.2*	34.3	36.9*
	6000	-	(n = 0)	13.0	17.5*	18.8	18.7	35.9	37.7	50.3	55.2**	34.2	37.2**
Machinists (n = 23)	1000	-	-	8.5	7.5	13.4	13.8	9.4	8.8	15.8	18.3	12.3	12.7
	2000	-	-	8.5	6.0*	15.9	16.9	8.1	8.1	20.0	20.0	14.0	13.8
	3000	-	-	5.0	5.0	20.6	24.7*	21.3	23.1	33.8	32.1	20.8	22.1
	4000	-	-	6.5	7.5	32.5	35.3	22.5	24.4	40.0	44.6	27.1	29.8*
	6000	-	(n = 0)	9.5	12.5	37.2	41.6	26.3	26.3	42.5	48.3***	30.6	34.3***
All NARP (N = 630)	1000	11.9	10.6	7.9	8.0	9.7	10.1	12.4	13.0*	15.7	17.0**	11.4	11.9*
	2000	9.4	8.8	6.4	6.1	9.6	9.8	13.6	14.4**	20.9	22.8**	12.4	13.0**
	3000	14.4	8.1	8.9	9.2	14.1	15.0*	21.3	22.4**	35.0	37.0**	19.4	20.4***
	4000	13.8	10.6	13.7	14.3	20.9	22.3**	27.9	30.0***	44.6	47.7***	26.3	28.1***
	6000	18.1	11.3	15.6	16.9	22.4	24.1**	31.6	32.9**	48.2	50.5***	29.0	30.5***

* p < .05

** p < .01

*** p < .001

DISCUSSION

It should be emphasized that these results reflect a group's collective audiometric experience and not individual differences. Although the observed differences between reference and current audiograms often appear to be small, they are statistically significant, where indicated. Further, although our results do not identify any group that has experienced significant shift of threshold sensitivity of 15 dB or more in accordance with criteria established by the Navy's Hearing Conservation Program³, undoubtedly individuals exist with differences that require follow-up audiometric evaluation and/or diagnostic testing.

Our data confirm the work of others^{15,19} in which the 4000 Hz notch characteristic of NIHL often includes a corresponding deficit at 6000 Hz, with approximately the same degree of loss at both frequencies.

Comparing the audiometric profiles in Figures 1 and 2 to the age-weighted "normalized" hearing threshold levels indicates that there may be an interaction between presbycusis and NIHL. If possible, it must be determined whether this interaction is additive or follows some other model and whether sensitivity to NIHL is affected by age. Our data suggest, as does previous work of Spoor²⁰ and of Helmkamp¹⁵, that the answers to these questions are not clear and that the interaction between presbycusis and NIHL is not purely additive.

Although DD Form 2215, used to record the reference audiogram, provides for the recording of information regarding the type, size, and issue of personal hearing protection devices, information on an individual's compliance and frequency of use are notoriously unreliable. This type of information is not currently a part of the medical data base of NOHIMS and, therefore, was not available for the NARF study population.

Two epidemiologic investigations recently completed at the Naval Health Research Center used other computerized data bases that provided medical and demographic information and only indirect exposure information^{21,22}. This study points out a significant feature of NOHIMS that provides comprehensive survey and medical information. Utilizing this information and new methodology a capability now exists that enables populations to be followed prospectively and to explore speculative causal relationships to help identify individuals or groups that may be at risk from exposure to a specific hazardous agent or a particular environment.

Although the audiometric profiles described are suggestive of chronic occupational noise exposure it has not been the intent of this study to explore cause and effect relationships. Future research efforts should address hearing loss within specific occupational groups and whether these deficits are more pronounced for older employees and at higher frequencies. More comprehensive noise exposure histories coupled with baseline and monitoring audiometric data will provide an excellent means to detect salient trends and determine their significance.

CONCLUSIONS

This study represents the first attempt to use NOHIMS' medical, personnel, and environmental data for research. The cross-referencing features and file structure of NOHIMS coupled with the MUMPS compatibility of COSTAR and MQL has provided the means to define cohorts of industrial populations and to evaluate health outcomes. In this study audiometric and noise survey data were extracted and analyzed for 12 civilian occupational groups. Nine of the 12 groups collectively experienced significant decrease in hearing ability as evidenced by elevation in mean hearing

threshold, at specified frequencies, at some time during the 18-month study period. Although audiometric and noise exposure information are the first data available from NOHIMS future research may be directed to a wide variety of medical outcomes in both civilian and military populations working in many different environments. As NOHIMS is implemented at multiple sites in the Navy over the next five years, prospective, retrospective, and cross-sectional epidemiologic research applications will be possible^{1,23}.

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19. ABSTRACT (Continue on reverse if necessary and identify by block number) Since 1984 the Branch Medical Clinic located at NAS North Island (NASNI), San Diego has collected comprehensive audiometric data on civilian personnel. The information gathered is recorded and stored in the Navy's Occupational Health Information Management System (NOHIMS) developed at the Naval Health Research Center in San Diego. Hearing tests are conducted at established intervals in accordance with the auditory component of the Navy Hearing Conservation Program. The study population consisted of 630 males employed at the Naval Air Rework Facility located at NASNI who had received both a reference (DD 2215) and a monitoring (DD 2216) audiogram between August 1984 and February 1986. At least one year elapsed between the two audiometric evaluations. The workers were grouped into 12 occupational categories based on the work environment, tasks performed, and assigned job title. Hearing tests were conducted in a standard sound treated audiometric chamber that met ANSI internal ambient sound level and certification requirements. Each ear was tested at 500, 1000, 2000, 3000, 4000, and 6000 Hz. The Medical Query Language (MQL), a high-level (Continued on back)			
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procedural language was applied to medical and personnel databases that are part of the prototype NOHIMS system. Nine of 12 groups collectively experienced some degree of significant deficit in mean hearing threshold, at specified frequencies, at some time during the 18-month study period. The audiometric profile for Metal Workers is that commonly associated with undifferentiated sensorineural hearing loss at high frequencies (3000 to 6000 Hz). This study represents the first attempt to use NOHIMS medical, personnel, and environmental data for research purposes. The cross-referencing features and file structure of NOHIMS coupled with the MUMPS compatibility of COSTAR and MQL has provided the means to define cohorts of industrial populations and to evaluate adverse health outcomes.

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